

Command and Control of Robotic Entities (C2ORE) in Future Combat Systems

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Down the streets of a foreign city, a small unmanned aerial vehicle (SUAV) scouts purposefully for signs of a hidden enemy. The SUAV swivels and moves in a new direction upon detecting an electronic signal transmission. With electronic eyes and ears, the SUAV detects heavily armed hostile forces emerging from a warehouse on the outskirts of town and instantly sends images to an unmanned communications relay hovering above the city.

C2ORE will support the C2D's F2BCI initiative through network-enabled battle command and other command and control efforts encompassing the entire FCS fleet of UAVs, UGVs and UGSs. Here, CPL Jerry Rogers from the Scout Platoon, 1st Battalion, 13th Armor Regiment, 3rd Brigade, 1st Armored Division, assembles an RQ-11 Raven UAV for aerial reconnaissance over Taji, Iraq, June 21, 2005. (U.S. Air Force photo by TSGT Russell E. Cooley IV, 1st Squadron Combat Camera.)

Like a chess master arranging pieces against an unsuspecting novice, master-mind decision support software begins cross-cueing firing units and additional sensors. Each Future Combat Systems (FCS) Unit of Action (UA) element moves with precision and shared intent to accomplish specific objectives.

Manned units take up positions to prevent threat escape, inhibit the arrival of enemy reinforcements and provide both direct and indirect fire while simultaneously monitoring live sensor updates from the UAV scouts.

The year is 2014 and a key enabler for unmanned and manned force collaboration is the U.S. Army Communications-Electronics Research Development and Engineering Center (CERDEC) technology program C2ORE.

FCS comprises a family of advanced, networked air- and ground-based maneuver, maneuver support and sustainment systems that will include manned and unmanned platforms. The UA is a “network-enabled” force equipped with a multitude of sensor arrays that will permit leaders and commanders to achieve dramatic improvements in mission success.

According to the *U.S. Army Future Force Operational and Organizational Plan*, by 2014, FCS intends to have approximately 398 unmanned systems in the objective UA. The C2ORE Army Technology Objective (ATO) is a 5-year effort being executed in the CERDEC Command and Control Directorate (C2D) to develop software services to support the multilevel system of unmanned systems, enabling teaming and tactical control of unmanned air and ground systems for the UA FCS Battle Command System.

C2ORE will also support the C2D’s Future Force Battle Command Integration

(F2BCI) initiative, an umbrella program encompassing Network Enabled Battle Command ATO and other command and control efforts within C2D. C2ORE software services will be developed and continually assessed through modeling and simulation demonstrations and live field experiments.

C2ORE will transition products to the FCS program in 2006, 2007, 2008 and 2009 per the Technology Transition Agreement with the UA Network Systems Integration Program Management Office (PM UA NSI) and the FCS Lead Systems Integrator (LSI). C2ORE will support risk mitigation of FCS battle command functionality by:

- Transitioning prototype software services that are fully FCS System-of-Systems Common Operating Environment compliant.
- Providing experimentation/analysis reports and lessons learned.
- Contributing to FCS Battle Command System Family of Services development — specifically planning and preparation services — battle command mission execution services and situation understanding services.



Unmanned systems and robots are a critical component of FCS and are already being deployed and operated in the theater of operations. Here, a 184th Explosive Ordnance Disposal robotics team deploys a Talon against an improvised explosive device near Baghdad, Iraq. (U.S. Army photo by SPC Jonathan Montgomery.)

C2ORE Software Services

There are two classes of C2ORE Software Services: Tactical Battle Command Services and Air/Ground Collaboration Services. These services will include, but are not limited to, information management techniques, intelligent agents and decision aids to support unmanned systems planning and replanning.

Tactical Battle Command Services.

Tactical Battle Command Services will be designed to dynamically monitor mission execution and provide courses of action (COAs) for unmanned air and ground systems based on a commander’s intent, evolving situation, resource availability and capability. Some services include unmanned aerial vehicle (UAV) flight path generation, unmanned ground vehicle (UGV) ground path generation, unattended ground sensor (UGS) placement, resource analysis, battlespace environment analysis services, dynamic COA generation, and modification and repair to operational plans. These services will integrate planning of unmanned entities into the FCS Battle Command System, thereby enabling a commander to create a plan with the optimal mix of both manned and unmanned platforms.

Air/Ground Collaboration Services.

Air/Ground Collaboration Services will be designed to enable teaming between UAV and UGV systems to provide a cohesive workflow to achieve operational missions. Services will include teamed missions where UAVs and UGVs work together to provide navigation assistance, terrain updates, obstacle detection and enemy situation reports. Likewise, Air/Ground Collaboration Services will also provide peer-to-peer UGS and UGV networks and collaborative group behaviors for UGVs and UAVs.



F2BCI is a CERDEC R&D effort that marshals the resources required to establish a groundbreaking, end-to-end battle command system supporting development and experimentation. Here, SFC Patrick Edwards operates a Force Battle Command Brigade and Below system during a series of demonstrations and experiments to test network-centric operations and the use of voice and data networks to link platforms and units during time-critical operations. (U.S. Navy photo by PH2 David Mercil, Fleet Combat Camera.)

All technology development and experiments undertaken by C2ORE will be in close coordination with the U.S. Army Training and Doctrine Command, PM UA NSI and the FCS LSI, and the Research Development and Engineering Command Robotics and Networks Integrated Product Teams. This coordination will serve to ensure validation of command and control functional requirements and information exchange requirements that drive software design.

Experimentation

Experimentation is essential in today's world to validate new technologies and software with current military computer systems and communications before fielding it to our warfighters. The C2ORE software services will be assessed through numerous laboratory demonstrations and live field experiments.

In August and September 2005, C2ORE participated in the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance On-the-Move (C4ISR OTM) Testbed Exercise at Fort Dix, NJ. The C4ISR OTM Testbed's purpose is to support FCS program risk

reduction through reducing identified C4ISR risk areas, investigating the value and contribution of emerging technologies and expanding the understanding of imprecisely defined conceptual requirements.

This venue will provide lessons learned and support for Joint Expeditionary Forces Experiment

2006 (JEFX06) and FCS Experiment 1.1. The OTM Testbed will use the C2ORE sensor planning and placement software for UGSs, UAVs and UGVs. Additionally, the C2ORE software will be used as the UGS controller for the surrogate FCS Tactical UGS and demonstrate control functionality such as on/sleep mode, exclusion zones and sensitivity.

During FY06, C2ORE will participate in JEFX06, the F2BCI Demonstration and FCS Experiment 1.1. JEFX06 will provide a multidimensional, multinational, multiservice environment for an end-to-end process of exploration, assessment and transition of capabilities within 6-24 months that will provide Joint and coalition warfighters with solutions to gaps identified in the Integrated Capability Review and risk assessment process

and through lessons learned in recent and current operations.

Specifically, JEFX06 will continue the exploration of network-centric operations (NCO) begun in JEFX04. NCO broadly describes the combination of emerging tactics, techniques and procedures that a fully — or even partially — networked force can employ to create a decisive warfighting advantage.

“My intent is to leverage JEFX series of experiments as a cornerstone of our experimentation plan,” Army Chief of Staff GEN Peter J. Schoomaker said. “At JEFX06, the plan is to experiment with the FCS capabilities that will spiral into our Current Force in the 2008 time frame and will be an integral part of the first fielded Unit of Action in 2014.” For JEFX06, PM UA NSI Joint Interagency Multi-National Interoperability and PM UA NSI Battle Command selected C2ORE software to provide UGS planning, placement and control tools for both Current and Future Force units in line with the FCS concept.

C2ORE will play a key role in the F2BCI Demonstration Initiative. F2BCI is a CERDEC research and development effort that marshals the



The FCS UA network-enabled force will be equipped with a variety of sensor arrays like those displayed on this Multifunctional Utility/Logistics and Equipment Vehicle. (U.S. Army photo courtesy of Program Manager UA.)



Tactical Battle Command and Air/Ground Collaboration Services will dynamically monitor mission execution and help combatant commanders develop COAs for deployment of critical unmanned air and ground systems. Here, a Northrop Grumman RQ-8A Fire Scout UAV test-fires a Mark-66 2.75-inch unguided rocket during weapons testing at Yuma Proving Ground, AZ. The Army hopes to spiral this technology and capability into the Current Force in the near future. (U.S. Army photo.)

management techniques and battle command decision aids.

The notional C2ORE Capstone Experiment will demonstrate the new integrated, system of unmanned systems concept within an FCS tactical scenario using UGSs, UAVs and UGVs. Ultimately, C2ORE algorithms and software services will assist commanders to successfully complete their missions by using unmanned systems within the UA.

Unmanned systems will be a critical part of FCS and the Future Force, so managing them to optimize their effectiveness and exploit their complementary capabilities becomes essential. Through the Technology Transition Agreement with PM UA NSI and the FCS LSI, C2D has been identified as a partner on the FCS Team. C2ORE will provide the tools and technology needed for the warfighter to successfully use and manage unmanned systems effectively and efficiently.

resources required to establish a groundbreaking, end-to-end battle command system supporting development and experimentation. F2BCI establishes a venue that supports holistic systems analysis, prototyping and experimentation to collectively address Current Force, UA, Unit of Employment (UE), Joint and coalition battle command issues.

F2BCI activities include a capstone exercise scheduled for fourth quarter, FY06 at the C4ISR OTM Testbed at Fort Dix. The exercise will provide insight into the performance and interaction of key C2ORE functionality as an SoS operating in an operationally relevant field environment. C2ORE will demonstrate UAV, UGV and UGS Intelligent Munitions Systems simulators in conjunction with live sensor planning, placement and control for a complete command and control thread between the UA and the UE.

The Road Ahead

Additional experiments will include two live field tests in FY07 and FY09 and a laboratory demonstration in FY08. Each experiment will assess

software services in a tactical scenario, using prototype FCS robotic systems, with military communications and personnel. An Experimentation and Analysis Report will be published detailing lessons learned, metrics evaluated and follow-on requirements for service development and enhancement.

Metrics to be evaluated during each experiment will include:

- Network load assessment based on parametric variance of scenario, including variances in available bandwidth, quality of service and latency.
- Robotics controller threat management effectiveness, including responsiveness of the battle command system to support the robotics controller to manage threat situations with unmanned systems.
- Level of Air-Ground Collaboration, measuring effectiveness and improved operational capabilities through collaboration of air and ground platforms.
- Decision cycle time for unmanned systems planning/replanning, measuring improvement and decreased decision cycle time through information

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